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ABSTRACT

This paper reviews the research related to the Earth Science Curriculum Project since the course first appeared in American Secondary schools in 1964. The author has identified nine research studies and several surveys concerned with ESCP since that time. Of the nine research studies, six were primarily concerned with achievement outcomes. The findings of the six studies seem to indicate that ESCP is superior to non-ESCP earth science in affecting student achievement. However, a clear-cut case for this could not be established. Two of the studies (Sargent, 1966 and Schirner, 1968) indicated that the combination of the right curriculum with the appropriate teacher was an important factor in influencing student outcomes. The surveys, all conducted by the ESCP Staff, pertained to student attitudes, teacher preparation programs and teacher professional background. The one survey discussed in this review indicates that the astronomy unit was a favorite of a majority of students who studied ESCP. The last section of the review is devoted to raising questions for further educational research. This is done through the aid of an instructional sequence model. (LC)

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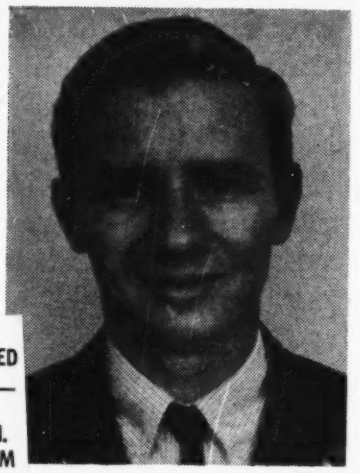

A Review of the Research Related to ESCP*

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ABSTRACT: It has been five years since the instructional materials produced by the Earth Science Curriculum Project first appeared in American secondary school classrooms. An extensive search revealed that nine research studies and several surveys pertaining to ESCP have been conducted in that time. Eight of these studies and one of the surveys are reported and commented on in this review. The ninth study was in progress at this writing. Six of the studies dealt with student achievement. The findings of the six studies seem to indicate that ESCP is superior to non-ESCP earth science in affecting student outcomes. However, a clear-cut case for this could not be established. More important were the indications in two of the studies (Sargent, 1966 and Schirner, 1968) that the combination of the right curriculum with the appropriate teacher was an important factor in influencing student outcomes. Two of the studies were analyses of the content of the trial editions of Unit IV, "The Earth and the Universe." Sonnier (1966) compared the conceptual content of college astronomy courses with the conceptual content of Unit IV. He determined that college astronomy courses provided adequate background for teachers of ESCP and that the more formal astronomy courses a teacher had in his background, the more independent he became of these courses in gaining new astronomy knowledge. Smith (1968) studied the conceptual content of Unit IV and especially Chapter 26, "The Universe and Its Origin," in terms of its suitability for ninth graders. He concluded that the reading level and sophistication of information were both too difficult for the target audience. The one survey discussed in this review indicates that the astronomy unit was a favorite of a majority of the students who studied ESCP. The last section of the review is devoted to raising questions for further educational research. This is done through the aid of an instructional sequence model. The model depicts the major factors influencing the design of instructional procedure. These factors are shown in the paradigm as Instructional Materials and Media, Pupil Characteristics and Behaviors, Teacher Characteristics and Behaviors, Possible Instructional Means, Expected Outcomes, and Outcomes of Instruction. Questions concerning needed research appear under these headings. The Earth Science Curriculum Project has made a substantial contribution to secondary school science education in this country. Its ultimate contribution is dependent upon careful consideration and wise utilization.

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INTRODUCTION

The first instructional materials produced by ESCP were used in secondary school classrooms five years ago. These preliminary materials were officially tested, evaluated, and revised twice during the two-year period 1964-1966. In the spring of 1967, the first commercial version of ESCP's *Investigating the Earth* became available.

During the 1966-1967 academic year, 446 schools in the U.S. and Canada reported teaching ESCP to 35,519 pupils (ESCP Newsletter, Number 13). Evidence indicates that interest in ESCP is continuing to develop both nationally and internationally. A modified ESCP course is now taught in Japan, Korea, and the Philippines (ESCP Newsletter, Number 15).

With all this interest and after two years of testing and three years of commercial availability, how much is known about the effectiveness of ESCP as an instructional package? What research has been done relative to ESCP and what do the results indicate? After an extensive search this investigator located nine research studies and several surveys concerned with ESCP. Of the nine research studies, six were primarily concerned with achievement outcomes and are discussed under that heading in this review. In two studies the content of the preliminary edition of Unit IV, "The Earth and The Universe" was analyzed. These are considered under the heading of "Content Analysis Studies." The ninth study, in progress while this was being written, will not be considered in this review.

The surveys, all conducted by the ESCP staff, pertained to student attitudes, teacher preparation programs, and teacher professional background. Since these surveys are discussed elsewhere in some detail*,

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they are referred to only when they are germane to the consideration of the eight research studies.

Because of the small number of studies and the diversity among them, it is difficult and hazardous to attempt any generalizations. With this in mind, the research has been reviewed. Comparisons between studies have been made where they seemed appropriate. Finally, the last section of this paper is devoted to suggesting questions for further research.

STUDIES DEALING WITH ACHIEVEMENT OUTCOMES

Of the six studies dealing with student achievement, four (The Psychological Corporation, 1965; Champlin and Hassard, 1966; Sargent, 1966; and Schirner, 1967) were conducted during the testing and revision phase of ESCP. The other two (Mooney, 1968 and Paull, Larson, and VandenAvond, 1969) were conducted after the two-year evaluation and revision of ESCP was completed.

During the first Evaluation Program (1964-65), a study was sponsored by ESCP and conducted by the Psychological Corporation. The study was national in scope, involving students and teachers in junior and senior high schools from various sections of the country. The experimental group consisted of those students (grades 8-12) who were studying ESCP as part of the Evaluation Program. Students studying conventional earth science served as a control group. Since the control group was composed solely of ninth graders (N = 2,170), only ninth graders in the experimental group (N = 3,537) could be studied for comparison purposes.

Both groups were pre-tested with the *Differential Aptitude Test* (DAT), both the *Verbal Reasoning* and *Numerical Ability* forms; and with the *Test on Science Knowledge* (TOSK), Part I, Facts, and Part II, Principles. The experimental group scored significantly higher than the control group on both pre-tests. As a result, the control group scores had to be adjusted statistically in order to make valid comparisons of the groups. Students in both groups were post-tested late in the school year with TOSK II (Principles) and the *ESCP Comprehensive Final.*

The ESCP group scored significantly higher than the control group on the *Comprehensive Final.* The investigators pointed out that this is not surprising since the examination was written to test the achievemen of ESCP students. The ESCP group also attained a significantly higher mean score on TOSK II (Principles). Again this finding was tempered by the researchers' caution that since the groups were not randomly selected, systematic bias such as better teachers and laboratory facilities for the ESCP groups may have influenced the results (Psychological Corporation, 1965).

Analysis of change in scores from the Pre-TOSK-II to Post-TOSK II showed that all grade levels (8-12) had an increase in score. The ESCP ninth graders made the greatest score gains, while the control group ninth graders made the least, being outscored by the 8th and 10th-12th grade groups. Boys scored significantly higher than girls on TOSK II, when the ESCP ninth graders were compared by sex.

Champlin and Hassard (1966) conducted a similar study with a smaller sample during the second year of the Evaluation Project. The experimental group consisted of 84 ninth graders studying ESCP and the control group was comprised of 94 ninth graders who studied an earth science course that had been established in the school five years previously. The groups, each consisting of four intact classes, were found to be similar in intelligence (*Otis Quick Scoring Test of Mental Abilities*), aptitude (*DAT, Verbal Reasoning and Numerical Ability*) and socio-economic background. The control group used one of the standard earth science textbooks and followed a syllabus written by local earth science teachers. This group spent about 50 per cent of their time in laboratory situations, while the ESCP group was involved in laboratory investigations approximately 75 per cent of the time.

Students in both groups were post-tested in the late spring of 1966 with the *ESCP Comprehensive Final* and TOSK II. Analysis of the results failed to indicate a statistically significant difference between the groups. In this study, as in the one previously discussed, the groups were not randomly selected and the teacher variable was not controlled. The fact that both the experimental and control groups were housed in the same school may also have affected the results, since students in each of the groups could have discussed what they were studying with one another.

Thus, The Psychological Corporation Study reported a "cautious" difference in favor of the experimental ESCP groups when compared with the control group non-ESCP students. Champlin and Hassard, on the other hand, reported no significant differences in a similar study with a smaller sample.

Sargent (1966) also conducted a study of student achievement during the second year of the Evaluation Program. In his study, rather than compare ESCP students with non-ESCP students, he compared students of permissive teachers with students of authoritarian teachers. Sargent enlisted the cooperation of 58 ESCP Test Center teachers for his study. Using the *McGee F-Scale* (developed for use in studying authoritarian personalities), he was able to identify 48 permissive and 9 authoritarian-type teachers. From this group, 30 permissive teachers and 714 of their students, and 5 authoritarian teachers and 120 of their students were

*See bibliography numbers 10, 24, 25, 28, 29.

randomly selected for further study. All the teachers and students were using ESCP materials.

The students were ranked in upper and lower quartiles and middle half groups according to their scores on the DAT (*Verbal Reasoning* and *Numerical Ability*). Teachers were grouped according to such variables as college major, semester hours in education courses, related science courses, and semester hours in physics and mathematics. Student scores on the *ESCP Comprehensive Final* were the bases for achievment comparisons.

The findings indicated that student achievement was not significantly different in authoritarian and permissive classrooms when the teacher variables listed above were considered. When the students of those authoritarian and permissive teachers who had 13 to 24 semester hours of education courses were compared with the students of those authoritarian teachers who had zero to 12 hours in education courses significant differences were noted favoring the former.

Several factors require consideration before the results of this study can be appropriately interpreted. First, the *McGee F-Scale,* which was used to categorize the teachers as permissive and authoritarian types, has been found, by McGee, to be reliable in predicting authoritarian or non-authoritarian behavior in only 58 per cent of the cases studied (McGee, 1955). Second, a sample of five authoritarians was subdivided on the basis of college major, number of hours of education, physics and mathematics courses. These teachers and their students were then compared to one another. When such a small sample is divided for comparison purposes, generalizations of the results are hazardous. Finally, some of the findings were based on a comparison of five authoritarian teachers to thirty permissive teachers. These findings must also be regarded cautiously.

Schirner (1968) also investigated the effects of the teacher variable, in a study which included students not using ESCP materials as well as ESCP students. He considered the effects of teacher verbal behavior, philosophical orientation, and course type on specific student outcomes such as critical thinking, understanding of processes and methods of science, understanding of scientific principles, factual knowledge, and knowledge of specific course content. Using the *Flanders Interaction Analysis Instrument**, Schirner observed 17 secondary school teachers who were teaching either ESCP or some other earth science course to a total of 750 students. The teachers also completed the *Teacher Educational Credo Preference Check List.* This checklist purports to classify teachers as either traditional or non-traditional in their beliefs. The 750 students were placed into upper, lower, and middle categories on the basis of DAT scores. They were also pre- and post-tested with five nationally standardized tests and a "traditional earth science final examination."

Analysis of the results reveals several interesting findings. ESCP students, on the basis of *Watson-Glaser Critical Thinking Appraisal Test* scores, were significantly better critical thinkers than the non-ESCP students. The students in groups representing both high and low ability appear to be slightly better achievers in an ESCP course. Students of high numerical ability appear to develop into significantly better critical thinkers in an ESCP course, while the same type of student seems to master facts better in a non-ESCP course than his ESCP counterpart.

Taking the teacher variable into account, Schirner found that a student having a direct teacher with traditional beliefs has an advantage in a non-ESCP course. On the other hand, a student with an indirect teacher with non-traditional beliefs has an advantage in an ESCP course and is at a disadvantage in a non-ESCP course. Non-ESCP students having a direct and traditional teacher scored significantly higher on all six tests than ESCP students who had direct and traditional teachers (Schirner, 1968). To Schirner, this reinforced the notion that *matching the right teacher to the right curriculum is extremely important.*

Finally, teachers who are extremely variable from laboratory to classroom situations in their direct-indirect verbal behavior are not as effective as moderately variable teachers.

Sargent's findings show a correlation between student achievement and teacher background in professional education courses. Schirner's findings indicate a correlation between teachers' values and verbal behavior and student achievement. Thus, the two studies have found the teacher variable to be important.

The four studies considered so far were conducted prior to the commercial marketing of the ESCP materials. In addition, two studies on student achievement have been conducted using the commercial version of ESCP.

Mooney (1968) conducted an achievement study to determine if ESCP was a viable alternative to the half-year earth science-half year physics course taught in ninth grade classes in the public schools of Richmond, Virginia. The study population consisted of 400 students divided equally and randomly into experimental and control groups. Two teachers taught the experimental groups and two taught the control groups. Both groups were shown to be statistically similar on the basis of scores on the *School and College Ability Test* (SCAT) and the *Sequential Test of Educational Pro-*

*An objective observational instrument developed by N. A. Flanders which enables the observer to classify teachers as being either direct or indirect in their classroom verbal behavior.

gress (STEP). Seventy pairs of students, who were matched according to scholastic ability, science achievement, age, and sex were selected for further study. These students were post-tested with the *Cooperative Advanced General Science Test* (CAGST), Form A.

Results from the testing and comparison of scores of the 70 matched pairs failed to demonstrate a significant difference in favor of either group. It was therefore determined that ESCP could replace the half-year earth science-half year physics course and produce the same achievement. The favorable attitudes shown by students and teachers toward ESCP also influenced this decision.

An interesting study was recently completed by Paull, Larson, and VandenAvond (1969b), who attempted to evaluate the potential effect of secondary school earth science education on student achievement in college geology courses. Students enrolled in ninth grade classes in general science, earth science, and ESCP were pre- and post-tested with TOSK, (Facts and Principles). Both the ESCP and non-ESCP earth science were elective courses. The general science course was used as a remedial course. A group of pre-geology college students and geology graduate students were administered the same test for comparison purposes. A 100-item college geology examination consisting of fact and terminology-oriented questions was also administered to the ninth graders as well as to students enrolled in a beginning college geology class. Comparisons were also made between college student scores and those attained by 11 high ability ninth graders from the ESCP group.

When the pre- and post-TOSK scores of the three ninth grade groups were compared, it was noted that the ESCP students made significantly greater gains than the general science and earth science students. When the post-TOSK scores for the high ability ESCP ninth graders were compared to pre-TOSK college student scores, the mean for the ninth graders (94.8) was 4.6 points higher than the pre-geology college students' mean (90.2). In fact, the mean of all ESCP students (83.0) was not dramatically less than that of the college students.

When college geology examination scores were compared, the college students enrolled in the geology course obtained a mean of 70.2, while the secondary school earth science students had a mean of 55.2. Two factors involving these examination scores are worthy of note. First, the authors indicated that under the normal procedures used by the Geology Department at the University of Wisconsin—Milwaukee, the examination results would have been curved upward six points. Had this been done to the ESCP ninth grade scores, many students would have received a grade of "D" or better on the examination, with two per cent of the students receiving a "B" or better. Secondly, the scores of the ESCP students, the non-ESCP earth science students, and high ability ESCP students were quite similar (54.7, 55.6, 56.7, respectively) on the college geology examination. Here the authors noted that the highly personalized and factual nature of the college geology examination was too strong to discriminate among the ninth graders.

From the findings of this study, the investigators concluded that ESCP is an effective program for improving the scientific understandings and abilities of students. They also suggest that students who study ESCP under well qualified teachers will be better prepared for college geology than those who do not. This suggested to the investigators the possible necessity for two introductory college geology courses with placement examinations, such as TOSK, used to guide students to the appropriate course. Another conclusion based on TOSK results was that ESCP students with high school biology, physics, and chemistry still ahead of them are already close to the science ability level of present college students.

In this study, as in others, the teacher variable was not controlled; therefore, one does not know if systematic bias in favor of the ESCP group was operating. Two teachers were compared on the basis of background and experience, but both were in the ESCP group. It may also be presumptuous to assume, based on TOSK scores, that ESCP ninth graders are close to the science ability of college students simply because they studied ESCP. First, TOSK is an achievement test not an ability test. Second, one might question whether or not TOSK is an appropriate achievement test for students who have studied high school biology, physics, and chemistry. It is possible that it is not, and therefore would not yield an accurate assessment of the achievement of such students now on the college level.

Of the six achievement studies reviewed, five made comparisons between students studying ESCP and students studying some other earth science or earth science-physical science course. Three studies, those by The Psychological Corporation, Schirner, and Paull, Larson, and VandenAvond, observed significant achievement differences favoring ESCP students. Two studies, one by Champlin and Hassard and one by Mooney, observed no significant achievement differences between experimental and control groups. The sixth study, by Sargent, compared ESCP students to one another on the basis of the kind of teacher they had. The results of this study indicated that teachers with professional education courses in their background had students who achieved better than the students of teachers who did not have many education course credits. From so few studies one cannot make a strong case for the superiority of ESCP over traditional earth science. There are indications that this might be true. Perhaps, more meaningful are the indi-

cations from the Schirner and Sargent studies that *the right combination of teacher and curriculum are more important than the curriculum by itself.*

CONTENT ANALYSIS STUDIES

By content analysis this review refers specifically to the science facts, principles, and concepts in the textbooks, their presentation and readability. The two content analysis studies deal with the astronomy section of *Investigating the Earth.*

Sonnier (1966) investigated how the conceptual content in college level astronomy courses compared with the conceptual content in the ESCP astronomy unit. He took 119 "astronomy ideas" from the ESCP text and submitted them to three groups of judges. Group I was composed of 59 ESCP writers, Steering Committee and Advisory Board members, and teachers in the Evaluation Program. Twenty-three ESCP teachers not in the Evaluation Program comprised Group II. Group III was composed of 22 college and university astronomy instructors.

Judges in the first two groups were asked to indicate where they had learned each of the 119 "astronomy ideas." Group III was asked to indicate whether or not they include each idea in the teaching of their courses.

In correlating Group I and II responses with their formal training in astronomy, Sonnier found that respondents with an increasing number of hours in astronomy reported having learned a decreasing number of the selected "astronomy ideas" either in college courses or from the ESCP text. This was taken as an indication that the more formal training one had in astronomy the more independent he became of knowledge from these courses, and that professional readings and activities became the more meaningful source of knowledge. Sonnier also concluded that college level astronomy courses were well suited for preparing teachers to teach the ESCP astronomy content.

It is difficult to reflect meaningfully on the implications of this study for earth science teacher education. It seems safe to assume, and Sonnier's study shows this, that the content of formal astronomy courses presents sufficient subject matter background for earth science teachers. A more critical factor is whether the material is presented to the future teacher in such a way as to make clear its relevance to an understanding and an appreciation of the earth and its place in the universe.

*Smith defines a concept as " . . . the process of abstracting a meaningful and insightful understanding from the common elements in a series of related or associate circumstances and for which a label or language symbol commonly exists."

The conceptual content of Unit IV, "The Earth and the Universe," in the preliminary version of the ESCP text were studied by Smith (1968)*. Chapter 26 "The Universe and Its Origin" was selected for detailed analysis because it seemed to involve a great many concepts. He sought to determine:

1) which concepts were treated explicitly and which were treated implicitly,
2) whether there was a hierarchical conceptual structure within the unit,
3) what level of sophistication was required to understand the materials presented, and
4) what professional judgment could be rendered relative to the suitability of the text for the target audience.

Although Smith's analysis is subjective, it is both detailed and thoughtful and the study contains numerous specific examples to illustrate his points. He concluded that Unit IV contained a heavy explicit concept load and a much greater implicit concept load, and " . . . is almost certainly projecting a level of sophistication to junior high school students which extremely few of them would possess" (Smith, 1968). He also determined that the material was not concept-oriented, but descriptive and narrative in style at a rather sophisticated level. Calling upon his professional experience and judgment, Smith concluded that the material was not well organized, lacked conceptual continuity, assumed unrealistic backgrounds, and had surprising omissions.

Data obtained by Kline (1966) from the ESCP staff seemed to reinforce part of Smith's conclusions. The staff found the reading level of the preliminary version to be quite variable, ranging from seventh grade to college level, with an average level of 11th-12th grade. Kline also observed that the reading level of the second experimental edition of *Investigating the Earth* was reduced to 9th-10th grade.

It is interesting to note, Smith's criticisms notwithstanding, that the astronomy unit was one of the most popular with students during both years of the Evaluation Program, according to the results of a survey conducted by the ESCP staff (NL 13). In the survey, six students of each teacher in the 1964-65 and 1965-66 Evaluation Programs completed a questionnaire. Teachers were asked to distribute the questionnaires equally among boys and girls at high, average, and low ability levels. Four hundred and thirty-five questionnaires were returned.

Eighty per cent of the students said they would recommend ESCP to their friends for the following year. Better than eighty per cent reported that they wanted to attend college and half of these said they would like to major in science. This last statement may be an indication that ESCP has a positive, if only temporary, effect on student attitudes toward science.

The two content analysis studies were quite different. Sonnier reached the conclusion that college astronomy courses appear to contain content appropriate for ESCP teachers who take such courses and that the more formal training in astronomy a teacher has, the more he learns on his own. Smith's study raises serious questions about reading level and sophistication of content in Unit IV, "The Earth and the Universe," and in particular Chapter 26, "Universe and Its Origin." The reading level appears to have been reduced significantly in the second experimental edition of *Investigating the Earth*. The question of concept difficulty remains, perhaps to be answered best by those teachers and students who use ESCP.

NEEDED RESEARCH

Since the number of studies is so small and their nature so diverse, it is not possible to focus on any traceable patterns of research findings. Perspective is needed, however, on areas offering the most promising opportunities for meaningful research. One way to facilitate the attainment of this perspective is to consider the available research on ESCP against an instructional sequence model, such as that developed by Ramsey and Howe (1969c) as shown in Figure 1.

To the left of the paradigm three major sources of input for the Design of Instructional Procedure are shown. These sources are Instructional Materials and Media, Pupil Characteristics and Behaviors, and Teacher Characteristics and Behaviors. Also serving as input sources for Design of Instructional Procedure are possible Instructional Means and Expected Outcomes. These sources of input are both predetermined and redetermined. That is, they are planned for prior to instruction and are reevaluated and altered during and after the actual instruction. Examples of Possible Instructional Means (upper right) and Expected Outcomes (lower right) are listed.

To say that the instructional sequence is complex and consists of many variables is to understate the case. Quite often in the physical and natural sciences the researcher knows what variables he must control in order to isolate one for investigation. In studies dealing with human behavior, it is impossible to recognize, let alone control, all the interrelated variables in order to focus attention on just one variable, such as achievement. Accordingly, any instructional model is necessarily a simplified and incomplete view of the educational process and must not be taken to include all possible considerations.

With this model and its limitations in mind, let us suggest opportunities for basic educational research concerning ESCP that may pay off in terms of increased understanding of the instructional process.

Instructional Materials and Media

ESCP has expended a great deal of effort to develop an instructional package. It is generally taken for granted that the content within the text is more current than that in previous texts. Apparently textbook publishers think so too, because recent revisions of "old" earth science texts reflect, in large measure, the content, style, and layout of the ESCP text, *Investigating the Earth*. If we grant that the content is more up to date, can we also say that it is more appropriate for or better presented to the average 9th grade student? This is still a moot question.

ESCP has sponsored and encouraged the development of films, slides, overhead projectuals, and supplementary reading materials. How are these materials being utilized in ESCP classrooms? What effect are they having on instructional outcomes? Can the same outcomes be produced in ESCP classes without using any of these supplementary materials? Has ESCP made the best possible use of the multi-media approach in attempting to promote inquiry, stimulate critical thinking, and help students develop concepts? For example, are parts of *Investigating the Earth* appropriate for programmed instruction?

Dean Chalmer Roy charged, in an address to the members of the first ESCP writing conference, ". . . our materials must meet the requirements set forth by the NSTA Curriculum Committee" (ESCP Newsletter, Number 4). This committee in a publication entitled *Theory Into Action* listed seven conceptual schemes and five major processes of science that must be considered when attempting to develop meaningful science curricula. How well does the ESCP material meet these requirements?*

Pupil Characteristics and Behavior

The major question to be answered here is for which students is ESCP suited. Can it be presented without modification to students of all ability levels? If not, can it be tailored to individual needs? Conflicting opinions are afoot concerning this question. Empirical evidence seems essential.

Teacher Characteristics and Behaviors

Due to their personalities, experiences, educational background, interests, and special abilities, teachers exhibit behaviors which influence their teaching styles and the psychological setting of their classrooms. Both teaching styles and classroom psychological setting

*As this review was being written, a dissertation by Musa Qutub entitled "The Objectives of the Earth Science Curriculum Project; An Evaluation of Their Achievement" was in progress.

have long been recognized as factors affecting student learning. What are the characteristics and styles of effective ESCP teachers? Are there certain traits that one might consider before assigning or soliciting a teacher to teach *Investigating the Earth?* This may be one of the most fruitful areas in educational research in terms of potential payoff as indicated in research reviews by Ramsey and Howe (1969a, 1969b, 1969c), Schirner's study (1968); and to some extent those of Paull *et al.* (1969a, 1969b) and Sargent (1966).

Possible Instructional Means

Programmed Material as a possible mode of instruction has been discussed previously. Team teaching, computer-assisted instruction, and individualized programs are other types of instructional methods with which ESCP might be utilized and studied.

Five studies discussed in this review compared ESCP to "traditional" courses, the implication being that the two courses are somehow different. In none of these studies was "traditional" clearly defined and thus it constitutes an uncontrolled variable. Comparative studies will become more meaningful when this factor is given greater consideration.

Among the philosophical tenets listed by ESCP is the statement that strong emphasis should be placed on laboratory and field study in which the students participate actively in the process of scientific inquiry rather than mechanically repeating "cookbook" labs. How do student outcomes in a laboratory course oriented to inquiry, such as ESCP, compare to student

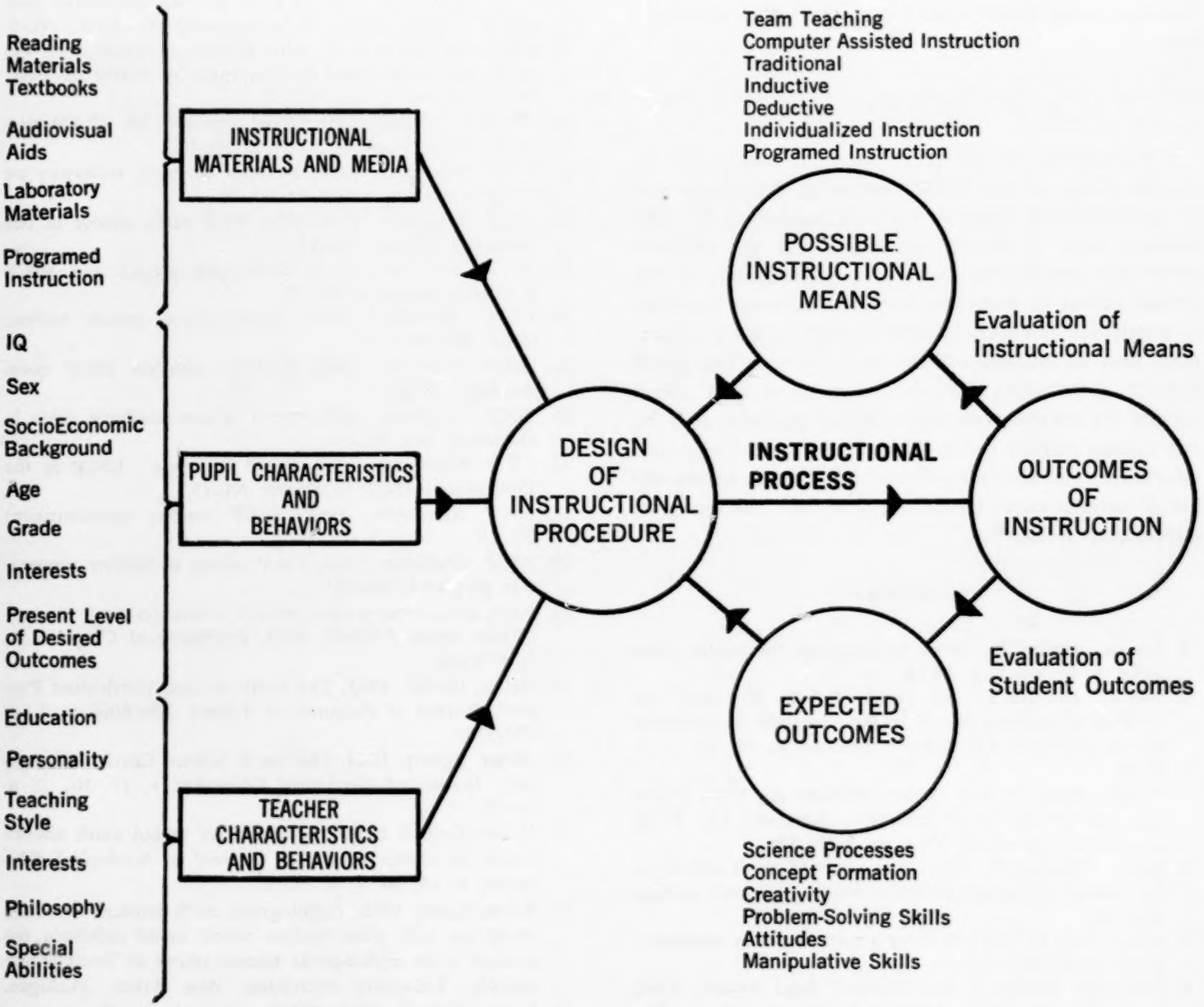

Figure 1. A model of an Instructional Sequence.

outcomes in a laboratory course consisting of non-inquiry exercises. Since ESCP is a laboratory-oriented course, does it effectively improve student skills in handling and understanding the proper use of lab equipment?

Expected Outcomes

Six of the studies reviewed were concerned with student outcomes in terms of mastery of specific content. The results, in general, were inconclusive. This may have been because certain important variables, such as teachers, facilities, *et cetera* were not controlled. Only the Schirner study (1968) assessed aspects of student outcomes, such as critical thinking and understanding of scientific processes. These are but two of the important student outcomes in addition to content mastery. Others are problem solving abilities, creativity, manipulative skills, and attitudes. The extent to which these are developed through instruction using ESCP materials needs further investigation.

SUMMARY

The purposes of this paper were to review the research related to the ESCP instructional package and to indicate those areas in need of further study. The analysis was, of course, subjective and the reviewer bears full responsibility for his interpretations. If this review serves to stimulate basic educational research, in particular research related to earth science education, then its mission will be accomplished. The Earth Science Curriculum Project has performed a useful service by creating an instructional package and by stimulating activity in the entire realm of earth science education. The ultimate value of ESCP can only be decided through careful consideration and well designed educational research.

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